

# **THE EFFECT OF FINANCIAL CRISIS ON THE LEAD-LAG RELATIONSHIP BETWEEN THE FUTURE AND SPOT MARKET**

by

Haofei Ma

BSc in Finance, Shandong University of Finance and Economics, 2014

PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF SCIENCE IN FINANCE

In the Master of Science in Finance Program  
of the  
Faculty  
of  
Business Administration

© Haofei Ma 2015

SIMON FRASER UNIVERSITY

Fall, 2015

All rights reserved. However, in accordance with the *Copyright Act of Canada*, this work may be reproduced, without authorization, under the conditions for *Fair Dealing*. Therefore, limited reproduction of this work for the purposes of private study, research, criticism, review and news reporting is likely to be in accordance with the law, particularly if cited appropriately.

# Approval

**Name:** **Haofei Ma**

**Degree:** **Master of Science in Finance**

**Title of Project:** **The effect of financial crisis on the lead-lag relationship between future and spot market.**

**Supervisory Committee:**

---

**Dr. Andrey Pavlov**  
Senior Supervisor  
Professor of Finance

---

**Dr. Phil Goddard**  
Second Reader  
Instructor

**Date Approved:**

## **Abstract**

This paper analyzed the effect of financial crisis on the lead-lag relationship between future and spot market. Plenty of papers already analyzed the relationship between these two variables but all this time they ignored one important fact: the financial crisis. Focusing on the 2008-2009 financial crisis allow us to document a very unlikely relationship. Specifically, we show that the S&P 500 index exhibits mean-reversion in the presence of controls from the futures market Even though the effect is small; it is significant and can still help investors facing the financial crisis to have confidence in their investment.

More generally, this paper examined the long-run relationship between the spot and futures prices in respond to the financial crisis. The results indicate the American market is not efficient during the financial crisis, and investors should be confident facing the financial crisis.

**Keywords:** Future and Spot Return; Financial Crisis; Lead-Lag Relationship; Mean reversion Effect

## **Acknowledgements**

I would like to extend my thanks to my supervisor, Andrey Pavlov, for his instructive advice and useful suggestions. In addition, I would like to give special thanks to Phil Goddard and Chandler Lutz for their support to my project.

## Table of Contents

Approval.....	ii
Abstract .....	iii
Acknowledgements .....	iv
Table of Contents.....	v
1: Introduction.....	1
2: Literature Review .....	3
3: The Data.....	5
4: Methodologies and Statistical Results .....	6
4.1 Unit Root Test .....	6
4.2 Co-integration Test.....	8
4.3 Granger Cause Test .....	9
4.4 Error Correlation Model.....	10
5: Conclusion.....	12
Bibliography.....	13

# 1: Introduction

This paper mainly discusses the lead-lag relationship between the price of future and spot market and the effects of financial crisis on the relationship above. Experientially, investors can use the price of the stock index future to predict the price pattern of underlying asset. More importantly, I investigate whether the recent financial crisis could affect the relationship between these two markets.

Based on my data and research, I can obtain the conclusion that co-integration relationship between the yield sequences of both price index truly exists. Meanwhile, in the crisis period, the last spot return will have significant negative effect on the current spot return. Even though the mean-reversion effect was small, it was still good evidence that the market can heal itself from the crisis eventually.

The stock index future, also called share price index future, designed to protect value by transferring risks from one party to another<sup>1</sup>. The stock index future is a contract that both buyers and sellers at present agree to trade a specific amount of share at a predetermined price in the future. Gradually, the stock index future becomes a convenient tool for kinds of investors to hedge their risk.

Due to the efficient market hypothesis<sup>2</sup>, all relevant information would be processed and reflected simultaneously into both future and spot market, limiting the arbitrage opportunities. However, there are amounts of empirical evidence against the hypothesis above; saying market is imperfections.

Many cases proved that asymmetric information and transaction costs could undermine the efficient market hypothesis and create arbitrage opportunity for speculators in both market. Especially, in the financial crisis circumstance, the financial market was in chaos and the lack of investors' confidence could exaggerate any small signal and then cause the market more volatility.

---

<sup>1</sup> The calm after the storm: implied volatility and future stock index returns, Thorben Manfred Lubnau & Neda Todorova (2014)

<sup>2</sup> The Efficient Market Hypothesis and Its Critics, Burton G. Malkiel (2003) The Journal of Economic Perspectives

Normally, the bankruptcy of the Lehman Brother<sup>3</sup> is regarded as the beginning of the 2008 financial crisis. Thus, I divided the data into two parts. I chose the return data during the financial crisis from 2008 to 2010 and then compared its statistical characteristics with that not in financial crisis.

At first, I processed the data to ensure all the data I used are stationary, an important assumption on which further statistical test must rely. Then, I used the Granger Cause test to distinguish the independent and dependent factor. Further, I run the Co-integration test and Error Correction Model to get the certain relationship between these two variables.

The remainder of this paper is organised as follows. Section 2 contains a brief discussion of relevant literature. Section 3 describes the data. Section 4 presents the major methodology used in this paper.

---

<sup>3</sup> Predictions from the man who forecast the meltdown. CNN, January 23, 2009. Retrieved July 7, 2012..

## 2: Literature Review

There are many studies about the relationship between the stock future and spot market since the birthday of the stock index future. Theoretically, Jan Tinbergen<sup>4</sup>, Frederick V. Waugh<sup>5</sup> and C. E. Ferguson<sup>6</sup> used the cobweb model to analyse dynamic price condition. Based on their theory, the spot market needed the future market to achieve equilibrium.

Barry Goss<sup>7</sup> provided another theory, the rational expectation hypothesis, to explain the relationship between the future and spot market. Based on this theory, future price is the rational expectation on the price in the future and the unbiased estimation of the spot price when the contract expires. These theories above are the solid foundation for the further empirical study.

When it comes to the empirical study, there are also plenty of papers working on this topic. Ghosh (1993) applies EG co-integration test to analyse the long-run relationship between S&P 500 index and futures prices from June 1986 to December 1989, showing that there existed a co-integration relationship between these two variables. Wahab and Lashgari (1993) drew the same conclusion using the data from 1988 to 1992.

In 1995, Tse achieved distinguished accomplishment by utilizing 10-min data for analysing the lead-lag relationship between FTSE 100 future contract and FTSE 100 stock index. The involvement of the high frequency trade data provided a new view about the changing relationship between these two.

Chris Brooks Alistair G. Rew, Stuart Ritson (2001) revealed several trading strategy based on their examination about lead-lag relationship between the FTSE 100 index and index future price.

Yong Ge and Delei Ye (2008) discovered the co-integration relationship between the stock future and spot price in China. They found very strong relationship in Chinese market, a good sign for investors to speculate.

---

<sup>4</sup> Jan Tinbergen: An Appraisal of His Contributions to Economics, Bent Hansen (1969) The Swedish Journal of Economics

<sup>5</sup> Cobweb Models, Frederick (1964) , Journal of Farm Economics, Vol. 46, No. 4 (Nov., 1964), pp. 732-750

<sup>6</sup> Learning, Expectations, and the Cobweb Model, C. E. Ferguson (1960), Journal of Economics Bd. 20, H. 3/4 (1960), pp. 297-315

<sup>7</sup> Rational Expectations and Efficiency in Futures Markets, Barry Goss (1992), 147-160



Kuangnan Fang and Zhong Zhong Cai (2012) used quantile regression to explore the relationship of future and spot market at different ups and downs. The empirical results show that there is mutual guidance between index futures and spot prices in China market, and the spot market have a bigger role in price discovery in current stage.

Tatu Paasimaa (2010) presented that there existed a two-way causal relation between S&P 500 and SP and DJIA and DJ. Furthermore, unlike most results of mainstream studies, his study showed there was significant evidence of the two indexes leading the two futures. In his view, the relationship is current becoming more unstable and changing.

Dmytro Kovalchak(2012) used the Improved Partial Least Square Regression to test the relationship between the future and spot market in Russia. He discovered the same pattern as Tatu Passimaa did. The result also applied to the South Africa financial market based on Floros (2009).

ShiQing Xia and JiaJun Huang (2013) applied a vector error correction model (VECM) and an impulse response function to conduct an empirical analysis on the price discovery function of index futures in China. They also found a solid long-run co-integration relationship between the CSI 300 index and its index. There is also strong evident that any shocks from the spot market influenced the futures market for long period, but not vice versa.

Pinar Evrim Mandaci (2013) examined the long-run relationship between the stock future price and other derivatives market. The paper not only proved the efficiency of the Turkish financial market but also stated the long-run co-integration relationship among its financial system.

These papers mentioned above provided a solid evidence and feasible methodologies I needed in my paper to prove the co-integration relationship between the stock spot return and stock index future return. However, these papers did not consider the impact of financial crisis, which could increase the correlation among different asset sectors. Therefore, this paper used the same methodologies mentioned before and tried to figure out the impact of the financial crisis on the relationship between these two markets.

### 3: The Data

In this paper, all the data are from the Bloomberg. The daily data cover from Jun 2001 to Oct 2015 and comprises total 3468 pairs of prices in the database.

In order to research the specific effect of the financial crisis on the relationship between the stock index future and spot market, I divided the time series into two parts; one part did not cover the financial crisis period, the other one did.

Based on the widely accepted result<sup>8</sup>, the future price usually leads the spot price 15-30 minutes. Therefore, for the stock index futures contract, I used the price 20 minutes ahead the spot closed price employed in the database.

In order to choose the most representative stock future contract, I preferred to use the contracts nearest to their expiration date, which usually are more liquidity than others are. Moreover, I switched to contracts that rolled over to next contract, since I want to diminish the converging relationship between the stock index future and spot price.

Specifically, I would like to use the  $S_t$  and  $F_t$  to represent S&P500 stock spot price and the E-mini S&P500 stock future price at any time  $t$ . Afterwards I turn the price data into log return series, a stationary series data.  $\Delta S_t$  and  $\Delta F_t$  represented the log return of the stock spot price and stock index future price correspondingly.

---

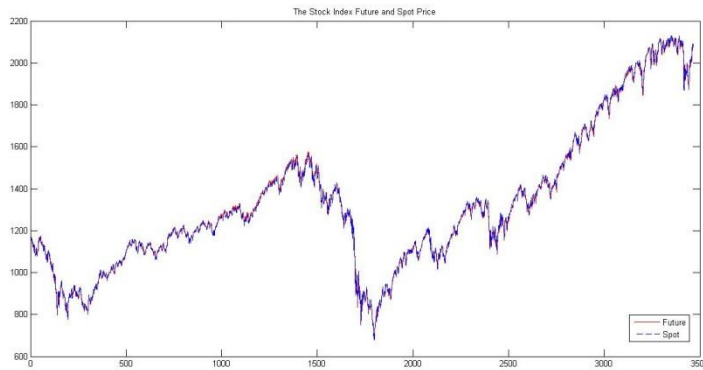
<sup>8</sup> Lead-lag relationship between spot index and futures price of the nikkei stock average, Y.K. Tse (2006), Journal of Forecasting, Volume 14, Issue 7, pages 553–563

## 4: Methodologies and Statistical Results

### 4.1 Unit Root Test

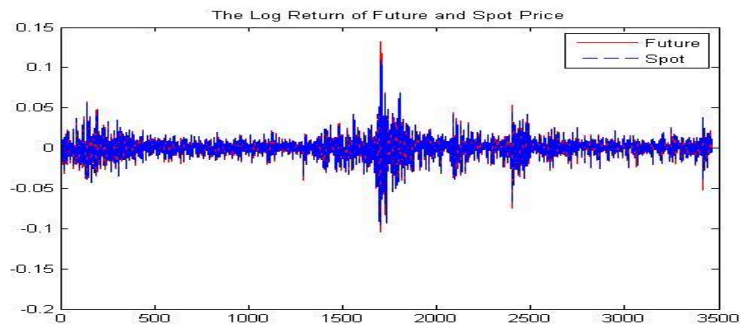
From the table below, it is easy to observe how similar these two price look like and then it is difficult to decide the lead-lag relationship clearly.

*Figure 4.1 the Price of both Future and Spot*



It is obvious that the price data are not stationary series. In order to detect the lead-lag relationship between these two prices, the data must be transformed to stationary, which also means that the trend in the series should be deleted. Dickey, D. (1979) provided a feasible way to delete the trend and create a stationary series- calculate the log returns of both and plot them together.

*Figure 4.2 the log Return of Both the Future and Spot*



In order to get statistical results, I used the augment Dickey-Fuller test<sup>9</sup> to check their stationary. Autoregressive unit root tests are based on testing the null hypothesis that  $\phi = 1$  (difference stationary) against the alternative hypothesis that  $\phi < 1$  (trend stationary). They are called unit root tests because under the null hypothesis the autoregressive polynomial of  $z_t$ ,  $\phi(z) = (1 - \phi z) = 0$ , has a root equal to unity<sup>10</sup>. The regressions that ADF test needs are as following.

$$\Delta \text{Log} S_t = \alpha + \gamma \cdot \text{Log} S_{t-1} + \delta \cdot t + \theta \cdot \Delta \text{Log} S_{t-1} + \varepsilon_t$$

$$\Delta \text{Log} F_t = \alpha + \gamma \cdot \text{Log} F_{t-1} + \delta \cdot t + \theta \cdot \Delta \text{Log} F_{t-1} + \varepsilon_t$$

$$\Delta^2 \text{Log} S_t = \gamma \cdot \Delta \text{Log} S_{t-1} + \varepsilon_t$$

$$\Delta^2 \text{Log} F_t = \gamma \cdot \Delta \text{Log} F_{t-1} + \varepsilon_t$$

Passing the ADF test means the data are stationary and ready to do the Co-integration test. Thanks to the Matlab function adftest, I got the result that the log returns of both stock index future price and spot price passed the stationary test.

*Table 4.1 The result of ADF Test*

	pValue	Stat	cValue
Log return of Future	0.001	-57.0717	-1.9416
Log return of Spot	0.001	-57.4698	-1.9416

<sup>9</sup> Dickey, D. A.; Fuller, W. A. (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root". Journal of the American Statistical Association 74 (366): 427–431.

<sup>10</sup> <http://faculty.washington.edu/ezivot/econ584/notes/unitroot.pdf>

## 4.2 Co-integration Test

In order to test where there is a casual relationship between stock index future return and stock return, I need to make sure that there existed a specific co-integration regress. Given by the stationary series I tested above, the standard Engle-Granger two-step methodology<sup>11</sup> is applied appropriately.

The co-integrating regression would be given by

$$\text{Log}S_t = \gamma_0 + \gamma_1 \text{Log}F_t$$

The null hypothesis is no co-integration. The alternative hypothesis is that the equation is a co-integrating equation, meaning that the integrated variable must be significant.

With the help of Matlab function egcitest, I tested the co-integration by the EG way. Here is the result for two periods.

*Table 4.3 The result of Co-integration Test<sup>12</sup>*

	pValue	Stat	cValue
Normal Period	0.001	-86.1141	-3.3411
Financial Crisis Period	0.001	-35.6013	-3.3485

Because of the small pValue of the test, the result of test is significant against the null hypothesis. Therefore, the test showed very strong co-integration relationship between these two variables.

---

<sup>11</sup> Co-integration and Error Correlation: Representation, Estimation, and Testing, Robert F. Engle, C.W.J. Granger (1987), *Econometrica*, Volume 55 Issue 2 (1987), 251-276

<sup>12</sup> Considering the similarity of the statistical characteristics, I merged the results of prior financial crisis with that after the financial crisis. Similarly Hereinafter.

### 4.3 Granger Cause Test

Further, I used the Granger Cause test<sup>13</sup> to decide which variable dominates other in two different periods, the normal period and the financial crisis period.  $X_t$  is said not to Granger-cause  $Y_t$  if for all  $h > 0$   $F(Y_{t+h}|\omega_t) = F(Y_{t+h}|\omega_t - X_t)$  where  $F$  denotes the conditional distribution and  $\omega_t - X_t$  is all the information in the universe except series  $X_t$ . In plain words,  $X_t$  is said to not Granger-cause  $Y_t$  if  $X$  cannot help predict future  $Y$ <sup>14</sup>.

I regressed based on the equations below and compared the F stat of each of them. The null hypothesis is that Future Return does not Granger Cause Spot Return.

$$\Delta \text{Log} S_t = \sum_{j=1}^p A_{11,j} \Delta \text{Log} S_{t-j} + \sum_{j=1}^p A_{12,j} \Delta \text{Log} F_{t-j} + E_1(t)$$

$$\Delta \text{Log} F_t = \sum_{j=1}^p A_{21,j} \Delta \text{Log} S_{t-j} + \sum_{j=1}^p A_{22,j} \Delta \text{Log} F_{t-j} + E_2(t)$$

Once, Future Return G-causes Spot Return if the coefficients in A12 are jointly significantly different from zero. This can be tested by performing an F-test of the null hypothesis that  $A12 = 0$ , given assumptions of covariance stationarity on X1 and X2.

*Table 4.3 The result of Granger Cause Test*

	F-Stat	Critic Value
Normal Period	12.5902	3.8446
Financial Crisis Period	9.7423	3.0140

The result above showed very strong relationship that the stock index future return dominate the stock index spot return both in the normal period and in the financial crisis period.

<sup>13</sup> Statistical inferences in vector autoregressions with possibly integrated processes., Toda, H. Y and T. Yamamoto (1995), Journal of Econometrics, 66, 225-250.

<sup>14</sup> Notes on Testing Causality, Jin-Lung Lin (2008), Institute of Economics, Academia Sinica, National Chengchi University

## 4.4 Error Correlation Model

In order to figure out much more precise relationship between stock index future return and stock index return, I decided to use error correlation model<sup>15</sup> to regress these two variables.

To build an error correction model, I need to find the regression relates Y to a function of X. Moreover, it must be granted that the residuals of Y regressed on X must be stationary. This derivation of the error correction model starts with the assumption that both Y and X are integrated and demonstrates that the error correction model captures the equilibrium causal movements between these two co-integrated processes.<sup>16</sup>

The model applied to the equation below,

$$\Delta \text{Log} S_t = \beta_0 + \delta \hat{z}_{t-1} + \sum_{i=1}^r \beta_i \Delta \text{Log} S_{t-i} + \sum_{j=1}^s \alpha_j \Delta \text{Log} F_t + \varepsilon_t$$

Where  $\hat{z}_{t-1} = \text{Log} S_t - \hat{\gamma}_0 - \hat{\gamma}_1 \text{Log} F_t$

The  $\hat{z}_{t-1}$  is also the residual from the co-integration test.

---

<sup>15</sup> Dynamic Relations Between Macroeconomic Variables and the Japanese Stock Market: An Application of a Vector Error Correlation Model, Tarun K. Mukherjee & Atsuyuki Naka (1995), The Journal of Financial Research, Vol. XVIII, No. 2 223-237

<sup>16</sup> Not Just for Co-integration : Error Correction Models with Stationary Data , Luke Keele (2004), Department of Political Science Pennsylvania State University.

Table 4.4 The result of the Error Correlation

	Estimate	SE	tStat	pValue
Normal Period				
Intercept	0	0	0.06673	0.9468
$\delta$	-0.43418	0.016901	-25.689	0
$\beta$	0.054657	0.003	1.6991	0.0894
$\alpha$	0.97757	0.0031421	311.12	0
Financial Crisis Period				
Intercept	0	0	-0.004	0.9965
$\delta$	-0.4079	0.040536	-10.063	0
$\beta$	-0.030244	0.0073732	-4.1018	0
$\alpha$	0.98002	0.0072467	135.24	0

It is clearly to observe that stock index future return always has significant coefficient parameter, meaning it could explain above 90% movement of the stock index return. It is also strong evidence that the 15-30 minutes lead-lag relationship is solid.

When it comes to the autocorrelation coefficient of spot market, I could say that there is no strong autocorrelation in normal period, indicating the American equity market is efficient and equity price did not depend on its past.

When the market was in the financial crisis, the autocorrelation coefficient showed a slight Mean-Reversion phenomenon. The mean reversion of the spot return during the financial crisis showed that the index would tend to move back to the average price over time, especially for the mature market. Alina F.Serban (2010) and Jim Liew and Ryan Roberts (2013) drew the same conclusion that there existed the mean reversion in the American equity market during the financial crisis.



## **5: Conclusion**

Based on my research, I could draw the conclusion safely that co-integration relationship between the yields sequences of both price index existed all the time. The relationship between these return could be the significant signal for the investors to predict the stock index..

Moreover, the future market has a dominant influence on the spot market and the price discovery function of future market is significant all the time. It stressed the importance of the stock index future market in the whole financial system. Investors could fulfill their expectation in market by using future contract instead of trading immediately.

Finally, only in the crisis period, the last spot return will have significant negative effect on the current spot return. Even though the mean-reversion effect was small, it was still good evidence that the market can heal itself from the crisis eventually.

## Bibliography

- Abhyankar, A, 1998, Linear and nonlinear Granger causality: evidence from the UK stock index futures market. *Journal of Futures Markets* 18(5), 519-540
- Abhyankar, A, 1995, Return and volatility dynamics in the FTSE-100 stock index and stock index futures market. *Journal of Futures Markets* 15(4), 457-488
- Brooks, C, 1997, Linear and nonlinear forecast ability of daily sterling exchange rates. *Journal of Forecasting* 16, 125-145.
- Bai, J., & Perron, P, 2002, Computation and analysis of multiple structural change models. *Journal of applied Econometrics*, 18(1), 1-22
- Maslyuk, S., & Smyth, R, 2009, Cointegration between oil spot and future prices of the same and different grades in the presence of structural change. *Energy Policy*, 37(5), 1687-1693
- Ng, S. & Perron, P, 2003, Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), 1519–1554
- Zivot, E., & Andrews, D. W. K, 2002, Further evidence on the great crash, the oil price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, 20(1), 25–44
- Li, M.-Y. L, 2009, The dynamics of the relationship between spot and futures markets under high and low variance regimes. *Applied Stochastic Models in Business and Industry*, 25(6), 696–718. <http://dx.doi.org/10.1002/asmb.753>.
- ShiQing, X & JiaJun, H, 2013, Price Discovery Function of Index Futures in China: Evidence from daily Closing Prices *Economic and Political Studies*
- Jim, L & Ryan, R, 2013, U.S. Equity Mean-Reversion Examined. [www.mdpi.com/journal/risks](http://www.mdpi.com/journal/risks)
- Booth, G. Geoffrey, Raymond W. So, and Yiuman Tse, 1999, Price Discovery in the German Equity Index Derivatives Markets, *Journal of Futures Markets*, 19(6): 619-643
- Covrig, Vicentiu, David K. Ding, and Buen Sin Low, 2004, the Contribution of a Satellite Market to Price Discovery: Evidence from the Singapore Exchange, *Journal of Futures Markets*, 24(10): 981-1004
- Chris B, Alistari G. Rew, Stuart R, 2001, A trading strategy based on the lead-lag relationship between the spot index and futures contract for the FTSE 100, *International Journal of Forecasting* 17 (2001) 31-44
- Prnar, M, 2013, the long-run relationship between the spot and futures markets under multiple regime-shifts: Evidence from Turkish derivatives exchange, *Expert System with application* 40(2013) 4206-4212